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Original Research Article

Effect of Phosphorus and Sulphur Management on Growth and Yield Attributes of Linseed

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Keywords

Phosphorus and sulphur management, linseed, experiment

A B S T R A C T

A field experiment was conducted during *rabi*, 2011-12 to study the effect of phosphorus and sulphur management on growth and yield attributes of linseed. Application of 40 kg phosphorus ha^{-1} recorded highest values of all the growth characters and yield contributing characters which was significantly superior over its lower levels. Similarly, application of 30 kg sulphur ha^{-1} recorded the highest grain yield with improved growth parameters which was significantly superior over its lower levels. Foliar sprays of 2% DAP at flowering and capsule development recorded significantly higher grain yield with improved growth parameters as compared to no foliar spray. However, the effect of different Interaction among the parameters tested were found to be non-significant. (Key words: Linseed, Grain yield, phosphorus, sulphur)

Introduction

Linseed (*Linum usitatissimum* L.) is an important oilseed crop of central India, locally known as jawas. It has been grown from ancient time for flax (fiber) and for seed purpose which is rich in oil. It is purely a cool season *rabi* crop. Linseed is an important oilseed crop in India and occupies 468.0 thousand ha with productivity of 349 kg ha^{-1}. In Maharashtra linseed is grown on 68.0 thousand ha with productivity of 279 kg ha^{-1} which is well below national average (Anonymous, 2010). Among the nutrients, phosphorus and sulphur play important role in improving the quality and quantity of linseed. (Yawalkar *et al.*, 2002) Majority of cultivated area of the linseed needs fertilization for good yield as phosphorus and sulphur content in soil is low. Prasad and Prasad (2002) conducted two years field experiment on sulphur deficient soil on linseed with different sources and levels of sulphur. The highest seed yield was obtained with application of 30 kg sulphur ha^{-1} through gypsum which was significantly superior to other sources of sulphur. Phosphorus stimulates root development and growth in the seedling stage. It also stimulates fruit setting and seed formation. (Yawalkar *et al.*, 2002) Sulphur is involved in the chlorophyll formation and encourages vegetative growth. Sulphur is essential for the synthesis of certain amino acids and oils. (Das, 1996). It can be called as master nutrient for oilseed production. In present crop management condition in India, intensive agriculture is necessary due to limited land resources. Therefore, to meet the requirement of growing population, it is necessary to increase the productivity of the crop and nutrient management is one of the answers to this issue.

Materials and Methods

A field experiment on "Effect of Phosphorus and sulphur on growth, yield and economics of linseed" was carried out during *rabi* season of 2011-2012 at Agronomy Farm, College of Agriculture, Nagpur. Representative soil samples were taken randomly from 0-30 cm soil profile from the experimental site before sowing and were analysed for various physico-chemical properties. Soil of the experimental site was clayey in texture (clay % - 54.43) estimated by using Standard international Pipette method (Piper,1966), low in available nitrogen (198.43 kg ha^{-1}) estimated by using alkaline potassium permagnate method (Subbiah and Asija, 1956), low in available phosphorus (11.20 kg ha^{-1}) estimated by using Olsen's method (Jacksan, 1967)and low in available sulphur (7.16 mg ha^{-1}) estimated by using Turbidimetric method (Jackson, 1967) and very high in available potash (304.56 kg ha^{-1}) estimated by using flame photometer (Jackson, 1967).

Organic carbon content was medium (0.55%) estimated by using Walkey and Black method (Jackson, 1967) and soil reaction was slightly alkaline (PH- 7.6) estimated by using glass electrode pH mater(Jackson, 1967). The experiment was laid out in Factorial Randomized Block Design (FRBD) with 18 treatment combinations with net plot of 2.4 m x 3.0 m. Treatment combinations consisted of three levels of phosphorus (viz. P_1-20, P_2-30 and P_3-40 kg ha^{-1}), three levels of sulphur (viz. S_1-10, S_2-20 and S_3-30 kg ha^{-1}) and two levels of foliar spray (F_0 - No foliar spray and F_1 - foliar sprays of 2% DAP once at flowering and capsule development). Seed was treated with thirum @ 3 g kg^{-1} of seed to control seed borne diseases. The sowing of linseed variety NL-260 was done by drilling method keeping 30 cm distance between the rows. Recommended dose of nitrogen *i.e.* 60 kg N ha^{-1} was applied through urea and DAP to all treatments, in two equal splits first at sowing second at flower initiation, while phosphorus was applied through DAP and sulphur was applied through elemental sulphur as per treatments at the time of sowing. One foliar spray of 2% DAP was applied at flowering and capsule development of linseed crop.

Results and Discussion

Growth attributes

Plant height

Effect of phosphorus

Application of phosphorus had a significant effect on plant height at all growth stage of crop, except at 20 DAS. There was an increase in plant height with increasing levels of phosphorus. Maximum plant height was recorded with application of 40 kg phosphorus ha^{-1}, which was significantly superior over 20 and 30 kg phosphorus ha^{-1} at 40, 60, 80 DAS and at harvest. This might be due to more availability of phosphorus, which might have promoted the plant height. Results obtained are in close agreement with the findings of Thosar *et al.,* (1986), Jain *et al.,* (1989), Vashistha *et al.,* (1993) and Sune *et al.,* (2007).

Effect of sulphur

Application of sulphur had a significant effect on plant height at all growth stages, except at 20 DAS. There was an increase in plant height with increasing levels of sulphur. Highest plant height was recorded with application 30 kg S ha^{-1} which was significantly more over 10 kg S ha^{-1} and remained at par with 20 kg S ha^{-1} at 40 DAS, 80 DAS and at harvest. The significant increase in plant height with sulphur application might be attributed to direct and indirect involvement of sulphur in the photosynthetic process of plant. Similar results were also repoted by Jagtap *et al.,* (2003)

Effect of foliar spray

Foliar spray of 2% DAP had a significant influence on the plant height of linseed except at 20 and 40 DAS. More plant height was record with F_1 (Foliar spray of 2% DAP at flowering and capsule development) over F_0 (control) at 60 DAS, 80 DAS and at harvest. This might be due to better nutrient availability through foliar spray in linseed crop. Results obtained were in close agreement with the findings of Kumar *et al.,* (2008 b).

Interaction

The interaction effect among the levels of phosphorus, sulphur and foliar spray were found to be non-significant.

Number of branches plant^{-1}

Effect of phosphorus

Phosphorus application influenced the number of branches plant^{-1} significantly at all growth stages, except at 20 DAS. Maximum number of branches plant^{-1} were recorded with application of 40 kg Phosphorus ha^{-1} which was significantly superior over its lower levels at 40, 60, 80 DAS and at harvest. Similar results were also obtained by Sune *et al.,* (2006).

Effect of sulphur

Application of sulphur had a significant influence on number branches plant^{-1} of linseed at all stages of growth except at 20 DAS. Maximum number of branches plant^{-1} were recorded with application of 30 kg S ha^{-1} which was significantly superior over 10 and 20 kg S ha^{-1} at 60 DAS, 80 DAS and at harvest.

However, at 40 DAS, it remained at par with application of 20 Kg S ha^{-1}. Similar results were also obtained by Badiyala *et al.,* (1999), Banerjee *et al.,* (2001).

Effect of foliar spray

Foliar spray of 2% DAP at flowering and capsule development significantly increased the number of branches plant^{-1} at all growth stages, except at 20 and 40 DAS over no foliar spray of DAP. Similar results were also given by Chandrasekaran *et al.,* (2008).

Interaction

The interaction effect between Phosphorus and sulphur, Phosphorus and 2% DAP foliar spray, sulphur and 2% DAP foliar spray and Phosphorus, sulphur and 2% DAP foliar spray were found to be non-significant in influencing the number of branches plant^{-1} of linseed at any of the observation stage.

Dry matter plant^{-1}

Effect of phosphorus

Data on dry mater plant^{-1} indicated that application of phosphorus significantly increased the dry matter plant^{-1} of linseed, except at 20 DAS. Application 40 kg phosphorus ha^{-1} recorded maximum dry matter plant^{-1} over 20 and 30 kg phosphorus ha^{-1} at 40, 60, 80 DAS and at harvest.

Increase in dry matter production plant^{-1} might be the result of better growth and more number of branches which might have resulted in higher photosynthetic activity and formation of more photosynthate. These results are in confirmation with the findings of Idnani *et al.,* (1989), Jain *et al.,* (1989) and Sune *et al.,* (2006).

Effect of sulphur

Application of different sulphur levels had a significant influence on the dry matter production plant^{-1} at all growth stages, except at 20 DAS. Application of 30 kg S ha^{-1} recorded significantly more dry matter plant^{-1} over 10 and 20 kg S ha^{-1} at 40, 60, 80 DAS and at harvest.

Sulphur help in chlorophyll formation and encourages vegetative plant growth. It also increases root growth. Yawalkar *et al.,* (2002). Thus, increase in dry matter plant^{-1} with application of sulphur might be due to increase in metabolic activity. Similar result was also reported by Jagtap *et al.,* (2003).

Effect of foliar spray

Two foliar spray of 2% DAP at flowering and capsule development significantly increased the dry matter plant^{-1} at all stages of growth, except at 20 and 40 DAS. This might be due to better nutrient availability through foliar spray at crucial period of demand by the linseed crop. The results are in conformation with the findings of Dixit *et al.,* (2007), Chandrasekaran *et al.,* (2008) and Kumar *et al.,* (2008 b).

Interaction

The effect of different interaction among the parameters tested were found to be non-significant in affecting the dry matter accumulation plant^{-1}.

Number of capsules plant^{-1}

Effect of phosphorus

Application of each increasing level of phosphorus significantly increased the number of capsules plant^{-1}. Application of 40 kg phosphorus ha^{-1} recorded significantly highest number of capsules plant^{-1} (31.12) over 20 (23.01) and 30 kg phosphorus ha^{-1} (27.17). The numbers of capsules plant^{-1} were increased significantly with increasing phosphorus levels. This might be because of better growth of plant due to more availability of phosphorus and essential nutrient. Increase in yield attributes with increase in the levels of phosphorus were also reported by Tosar (1986), Awasti *et al.,* (1989), Jain *et al.,* (1989) and Tiwari *et al.,* (2001).

Effect of sulphur

Different levels of sulphur significantly influenced the number capsules plant^{-1}. Application of 30 kg S ha^{-1} recorded maximum number of capsules plant^{-1} which was significantly superior over 10 kg S ha^{-1} but at par with 20 kg S ha^{-1}. The number of capsules plant^{-1} were increased significantly with increase in sulphur levels. This might be because of better growth of plant due to more availability of sulphur. Increase in yield attributes with increase in the levels of sulphur was also reported by Aalukh *et al.,* (1989), Badiyala *et al.,* (1999) and Sune *et al.,* (2006).

Effect of foliar spray

Foliar application spray of 2% DAP at flowering and capsule development significantly increased the number of capsule plant^{-1} over no foliar spray of 2% DAP. This might be due to better growth of plant as a result of rapid and timely availability of nutrients through foliar spray, which might have helped in higher metabolic activity, increased flowering, capsule formation and capsule development. Similar result was also noticed by Aruna *et al.,* (2007).

Interaction

The various interaction effects were found to be non-significant in affecting the number of capsule plant^{-1} in linseed.

Seed yield

Seed yield plant^{-1}

Effect of phosphorus

Grain yield plant^{-1} increased significantly with each increasing level of phosphorus. Application of 40 kg phosphorus ha^{-1} recorded significantly highest seed yield plant^{-1} (2.62 g) over 20 kg (1.07 g) and 30 kg phosphorus ha^{-1} (1.80 g). This might be because of vigorous growth of crop due to availability of phosphorus leading to increase number of capsule plant^{-1} and improve seed formation which ultimately reflected as increase in seed yield plant^{-1}. Similar result was also reported by Sune *et al.,* (2006).

Effect of sulphur

Sulphur application influenced the seed yield plant^{-1} significantly. Application of 30 kg S ha^{-1} recorded significantly highest seed yield plant^{-1} (1.95 g) as compared to 10 kg S ha^{-1} (1.71 g) and 20 kg S ha^{-1} (1.83 g).

This might be due to sulphur stimulates seed formation in plant. Yawalkar *et al.,* (2002). Thus application of sulphur might have enhanced the seed formation in linseed plant resulting in to increased seed yield plant^{-1} and ultimately ha^{-1}. Similar results were also reported by Sune *et al.,* (2006) and Kumar *et al.,* (2008 b).

Effect of foliar spray

Foliar spray of 2% D.A.P at flowering and at capsule development recorded significant effect on seed yield plant^{-1}. Applications of 2% DAP at flowering and at capsule development registered significantly more seed production plant^{-1} over no foliar application of DAP. This might be due to better growth of plant as result of rapid and timely availability of nutrients which increased the seed formation and development. Similar result was also reported by Aruna *et al.,* (2007).

Interaction

The various interaction effects were non-significant.

Seed yield (q ha^{-1})

Effect of phosphorus

The seed yield ha^{-1} was significantly influenced by different levels of phosphorus. Highest seed yield of 8.72 q ha^{-1} was recorded with application of 40 kg phosphorus ha^{-1} which was significantly superior over seed yield obtained with 20 (5.12 q ha^{-1}) and 30 kg phosphorus ha^{-1} (6.93 q ha^{-1}).

Increase in the seed yield might be due to vigorous growth which might have helped in higher dry matter production resulting in more photosynthate accumulation in the sink which ultimately reflected in terms of higher seed yield. The results are in confirmation with the findings of Awasti *et al.,* (1989), Vashistha *et al.,* (1993), Pali *et al.,* (1995) and Sune *et al.,* (2006).

Effect of sulphur

Data revealed that various levels of sulphur significantly influenced the seed yield ha^{-1}. Highest seed yield of 7.50 q ha^{-1} was recorded with the application of 30 kg S ha^{-1} which was significantly superior over yields obtained with 10 kg (6.34 q) and 20 kg S ha^{-1} (6.94 q).

This might be because of better growth of plant due to availability of sulphur leading to increased number of capsule $plant^{-1}$ as seed yield is directly related to the growth and yield attributes. Similar results were also reported by Aulakh *et al.*, (1989), Chaubey *et al.*, (1992) and Badiyala *et al.*, (1999).

Effect of foliar spray

Data revealed that application 2% DAP at flowering and capsule development recorded 7.12 q of seed yield ha^{-1} which was significantly more over no foliar spray of DAP (6.72 q).

This might be due to better growth and development of plant due to rapid and timely availability of nutrients through foliar spray, which might have helped in higher metabolic activity and improved growth and yield parameters, which ultimately reflected as increased yield.

Similar results were also noticed by Aruna *et al.*, (2000), Kalpana *et al.*, (2003) and Dixit *et al.*, (2007).

Interaction

The interaction effect between levels of Phosphorus and sulphur, Phosphorus and foliar spray, sulphur and foliar spray and Phosphorus, sulphur and foliar spray were found to be non-significant.

Straw yield (q ha^{-1})

Effect of phosphorus

Each incremental level of phosphorus increased the straw yield of linseed significantly. Highest straw yield (28.84 q ha^{-1}) was obtained by application of 40 kg phosphorus ha^{-1} which was significantly superior over application 20 or 30 kg phosphorus ha^{-1} (19.37, 23.99 q ha^{-1} respectively). Higher straw production might be due to vigorous growth of the plant resulting into more dry matter accumulation. Idnani *et al.*, (1989), Tiwari *et al.*, (2001) and Sune *et al.*, (2006) also reported same results.

Effect of sulphur

Effect of sulphur levels on straw yield ha^{-1} was found significant. Application of 30 kg S ha^{-1} recorded the highest straw yield (25.86 q ha^{-1}) which significantly superior over application of 10 kg S ha^{-1} (22.56 q ha^{-1}) and 20 kg S ha^{-1} (24.08 q ha^{-1}). Higher straw production might be due to increased growth and yield parameters resulting into more dry matter accumulation plant $^{-1}$. Similar results were also reported by Chaubey and Dwivedi *et al.*, (1995) and Sune *et al.*, (2006).

Effect of foliar spray

Foliar spray of 2% DAP at flowering and capsule development recorded straw yield of 24.77q ha^{-1} which was significantly superior over no foliar spray of 2 % DAP (23.36 q ha^{-1}). Similar result was also reported by Raju *et al.*, (2008).

Interaction

The various interaction effects were found to be non-significant.

Mean Plant height (cm), Number of branches plant^{-1} and Dry matter (g) plant^{-1} as influenced by various treatments

Treatments	Plant height(cm)					Number of branches plant^{-1}					Dry matter (g) plant^{-1}				
	20 DAS	40 DAS	60 DAS	80 DAS	At harvest	20 DAS	40 DAS	60 DAS	80 DAS	At harvest	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
Phosphorus levels (P)															
P_1 (20 kg ha^{-1})	6.58	29.83	43.59	45.16	46.23	1.84	1.94	2.10	2.45	2.71	0.323	1.85	6.44	7.55	8.88
P_2 (30 kg ha^{-1})	6.73	32.41	51.63	53.66	54.64	1.93	2.33	2.60	2.97	3.23	0.323	2.61	8.27	9.30	10.94
P_3 (40 kg ha^{-1})	7.03	34.13	59.85	61.42	62.52	2.00	2.82	3.06	3.51	3.81	0.320	3.38	9.88	11.52	13.11
S.E. (m) ±	0.16	0.34	0.82	0.90	0.87	0.09	0.08	0.05	0.05	0.05	0.014	0.06	0.11	0.16	0.15
C.D. at 5%	N.S.	1.00	2.36	2.59	2.50	N.S.	0.24	0.14	0.13	0.13	N.S.	0.17	0.31	0.45	0.45
Sulphur levels (S)															
S_1 (10 kg ha^{-1})	6.72	31.10	49.28	51.12	52.22	1.90	2.10	2.41	2.74	3.03	0.306	2.29	7.56	8.91	10.13
S_2 (20 kg ha^{-1})	6.74	32.20	51.67	53.33	54.37	1.93	2.33	2.58	2.98	3.25	0.321	2.61	8.24	9.42	10.94
S_3 (30 kg ha^{-1})	6.88	33.07	54.12	55.80	56.80	1.94	2.55	2.87	3.21	3.48	0.339	2.94	8.78	10.04	11.86
S.E. (m) ±	0.16	0.34	0.82	0.90	0.87	0.09	0.08	0.05	0.05	0.05	0.014	0.06	0.11	0.16	0.15
C.D. at 5%	N.S.	1.00	2.36	2.59	2.50	N.S.	0.24	0.14	0.13	0.13	N.S.	0.17	0.31	0.45	0.45
Foliar spray of 2% DAP at flowering and capsule development (F)															
F_0 (No foliar spray)	6.77	31.79	50.58	52.28	53.35	1.91	2.26	2.53	2.90	3.19	0.318	2.55	8.05	9.27	10.77
F_1 (Two foliar spray)	6.78	32.46	52.80	54.54	55.58	1.93	2.39	2.70	3.04	3.32	0.326	2.68	8.34	9.65	11.18
S.E. (m) ±	0.13	0.28	0.67	0.73	0.71	0.07	0.07	0.04	0.04	0.04	0.011	0.04	0.09	0.13	0.13
C.D. at 5%	N.S.	N.S.	1.92	2.12	2.04	N.S.	N.S.	0.12	0.11	0.11	N.S.	N.S.	0.25	0.37	0.36
Interaction P x S															
S.E. (m) ±	0.28	0.60	1.42	1.56	1.51	0.15	0.14	0.09	0.09	0.08	0.024	0.11	0.19	0.27	0.26
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Interaction P x F															
S.E. (m) ±	0.23	0.49	1.16	1.27	1.23	0.12	0.12	0.07	0.06	0.07	0.019	0.09	0.15	0.22	0.22
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Interaction S x F															
S.E. (m) ±	0.23	0.49	1.16	1.27	1.23	0.12	0.12	0.07	0.06	0.07	0.019	0.09	0.15	0.22	0.22
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Interaction P x S x F															
S.E. (m) ±	0.40	0.85	2.01	2.21	2.13	0.23	0.21	0.12	0.11	0.11	0.034	0.15	0.26	0.39	0.38
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
G.M.	6.78	32.12	51.69	53.41	54.47	1.92	2.33	2.62	2.98	3.25	0.322	2.61	8.20	9.46	10.98

Mean no. of capsules $plant^{-1}$, seed yield (g $plant^{-1}$ and q ha^{-1}) and straw yield (q ha^{-1}) as influenced by various treatments

Treatments	No. of capsules $plant^{-1}$	Seed yield		Straw yield (q ha^{-1})
		g $plant^{-1}$	q ha^{-1}	
Phosphorus levels (P)				
P_1 (20 kg ha^{-1})	23.01	1.07	5.12	19.37
P_2 (30 kg ha^{-1})	27.17	1.8	6.93	23.99
P_3 (40 kg ha^{-1})	31.12	2.62	8.72	28.84
S.E. (m) ±	0.30	0.03	0.14	0.57
C.D. at 5%	0.87	0.10	0.40	1.64
Sulphur levels (S)				
S_1 (10 kg ha^{-1})	26.13	1.71	6.34	22.56
S_2 (20 kg ha^{-1})	27.2	1.83	6.94	24.08
S_3 (30 kg ha^{-1})	27.97	1.95	7.5	25.86
S.E. (m) ±	0.30	0.03	0.14	0.57
C.D. at 5%	0.87	0.10	0.40	1.64
Foliar spray of 2% DAP at flowering and capsule development (F)				
F_0 (No foliar spray)	26.67	1.78	6.72	23.36
F_1 (Two foliar spray)	27.53	1.87	7.12	24.77
S.E. (m) ±	0.24	0.03	0.11	0.46
C.D. at 5%	0.71	0.08	0.33	1.33
Interaction P x S				
S.E. (m) ±	0.52	0.06	0.24	0.98
C.D. at 5%	N.S.	N.S.	N.S.	N.S.
Interaction P x F				
S.E. (m) ±	0.42	0.05	0.20	0.80
C.D. at 5%	N.S.	N.S.	N.S.	N.S.
Interaction S x F				
S.E. (m) ±	0.42	0.05	0.20	0.80
C.D. at 5%	N.S.	N.S.	N.S.	N.S.
Interaction P x S x F				
S.E. (m) ±	0.74	0.08	0.34	1.39
C.D. at 5%	N.S.	N.S.	N.S.	N.S.
G.M.	27.10	1.83	6.92	24.07

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